# Glaciers of Europe—

# GLACIERS OF SWEDEN

*By* VALTER SCHYTT

## SATELLITE IMAGE ATLAS OF GLACIERS OF THE WORLD

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*Sweden has a total area of 314 square kilometers covered by glaciers, one of which (Storglaciären, in Swedish Lapland) is subject of the longest continuous series of mass-balance measurements in the world, initiated in 1945–46*

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*By* VALTER **SCHYTT**[1] [2]


## Abstract

The most recent glacier inventory lists a total glacier area for Sweden of 314 square kilometers. The first glaciological observations were made in 1807, but no further studies were carried out until the end of the century. The modern center for the study of Swedish glaciers is the Tarfala Glaciological Station in Kebnekaise, Lapland. At Storglaciären, in Kebnekaise, winter, summer, and net mass-balance measurements were begun in 1945–46, the longest continuous mass-balance series in the world. The first map of the Swedish glaciers was published in 1910, but it was not until good-quality topographic maps and aerial photographs were available in the 1960's that it was possible to produce an accurate map of the shape and extent of Swedish glaciers. This map was published in 1973 as part of the "Atlas of Glaciers in Northern Scandinavia." It includes maps at scales of 1:1,500,000, 1:600,000, 1:500,000, and 1:250,000. However, a few of the Swedish glaciers, for example Kårsajökeln and Storglaciären, had been mapped previously at larger scales. Satellite imagery has a very limited application for glaciological studies in Sweden because most of Sweden's glaciers are too small for the spatial resolution of the Landsat MSS sensors. Repetitive aerial photographic coverage is available.


# Introduction

## Occurrence of Glaciers

The total number of glaciers in Sweden has varied from one climatic epoch to another and from one glacier inventory to the next. Many glaciers are so small that a climatic warming, like the one experienced in the period between 1910 and 1940, could markedly reduce the area and volume of active glaciers to tiny patches of ice. All modern glacier inventories of Sweden have been based on aerial photographs, and it is often very difficult to distinguish between a small glacier and a large snow field, especially if the photographs happen to have been taken during a cold summer, when there is much residual snowpack.

However, the more recent inventories should be better than previous ones, because more photographic material has become available and all deviations from previous glacier maps have been assessed carefully. The results of three complete glacier inventories (Schytt, 1959; Vilborg, 1962; and Østrem and others, 1973) are summarized in table 1.

It was found during these inventories that the quality of the topographic maps, the scale of the aerial photographs, and the availability of several years of photographic coverage were the most important factors in achieving an acceptable final result. Table 2 provides information on the areas of the 20 largest glaciers in Sweden. Their locations are shown on figure 1.

[1] Stockholm University, Department of Physical Geography, S-10691 Stockholm, Sweden.
[2] Deceased on 30 March 1985.

TABLE 1.—*Glacier inventories of Sweden*

| Glaciologist | Source of data | Number of glaciers | Area of glaciers ($km^2$) |
|---|---|---|---|
| Schytt (1959) | One set of 1:65,000-scale aerial photographs acquired in 1958 and 1:200,000-scale topographic maps compiled from plane-table surveys in the late 1800's (ca. 1890). | 237 | 310 |
| Vilborg (1962) | Modification of Schytt's 1959 map, aerial photographs acquired during the years 1959–61, and extensive field observations. | 287 | 329 |
| Østrem and others (1973) | 1959 and 1963 aerial photographs and the new 1:100,000-scale topographic map series compiled from aerial stereophotogrammetric methods. | 294 | 314 |

## Observation of Glaciers

The Swedish high mountains are situated in a much more continental type of climate than most of the Norwegian mountains. Therefore, only a few massifs reach above the present-day glaciation level, and, when they do, the areas are too small to support any really large glaciers. There are nearly 30 glaciers in Norway, for example, that are larger than Sweden's largest glacier, Stourrajekna. Norway's largest glacier, Jostedalsbreen (487 $km^2$), covers 50 percent more area than all the Swedish glaciers combined. Furthermore, the Swedish glaciers are all situated far from populated areas and did not attract people's attention until the 1800's.

Although the first scientific glaciological observations were made by Göran Wahlenberg in 1807 (Wahlenberg, 1808), no further studies were carried out until the end of the century, when Fredrik Svenonius, Jonas Westman, Axel Hamberg, Axel Gavelin, and Fredrik Enquist became interested in them. Together they published "Die Gletscher Schwedens im Jahre 1908" ["The Swedish Glaciers in the Year 1908"] for the International Geological Congress, which was held in Stockholm in 1910 (Svenonius and others, 1910). Their publication is of great value, because it describes several glaciers before the great glacier retreat that started in about 1915.

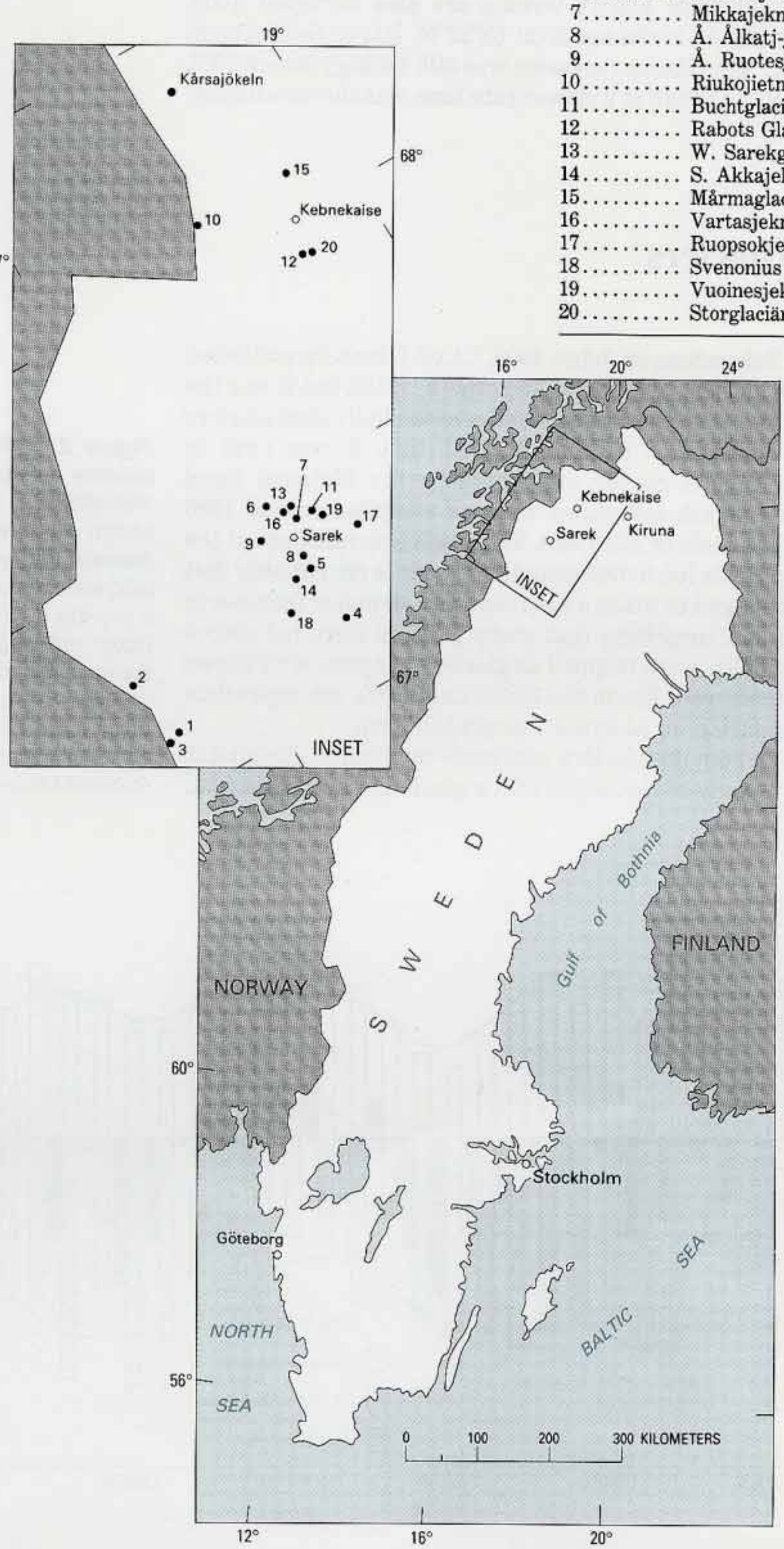
Another important contribution to historical study of Swedish glaciers was Fredrik Enquist's terrestrial photogrammetric mapping of the Kebnekaise glaciers in 1910. For this purpose he took a set of excellent-quality terrestrial photographs on 18- by 24-cm glass plates; these photographs show all glaciers and glacier termini in August 1910. Axel Hamberg began a comprehensive study of glaciers in the Sarek Mountains, especially of the glacier Mikkajekna (Mikkajökeln), in 1895 (Hamberg, 1896), but the longest and most continuous study of the variation in termini of a glacier is that of the glacier Kårsajökeln (fig. 1), which lies farther north (Ahlmann, 1929; Schytt, 1963).

The modern center for the study of Swedish glaciers is the Tarfala Glaciological Station in Kebnekaise, Lapland (see fig. 5). The station is situated 70 km west of Kiruna, 30 km from the end of the road, at 1,130 m elevation, about 400 m above the tree line. Two glaciers in the Tarfala Valley were surveyed in 1897 and several times between 1908 and 1920. In the spring of 1946, this author began a series of mass-balance studies of Storglaciären that are still going on (Schytt, 1981; Grudd and Jannson,

TABLE 2.—*Areas of the largest glaciers in Sweden (Information from Østrem and others, 1973)*

| Number (see fig. 1) | Glacier name | Area ($km^2$) |
|---|---|---|
| 1.......... | Stourrajekna | 12.75 |
| 2.......... | Álmaijekna | 12.15 |
| 3.......... | Salajekna | 11.10 |
| 4.......... | Pårtejekna | 11.10 |
| 5.......... | Jåkåtjkaskajekna | 9.96 |
| 6.......... | Suottasjekna | 8.11 |
| 7.......... | Mikkajekna | 7.62 |
| 8.......... | Å. Ålkatj-jekna | 6.56 |
| 9.......... | Å. Ruotesjekna | 5.41 |
| 10.......... | Riukojietna | 4.99 |
| 11.......... | Buchtglaciären | 4.65 |
| 12.......... | Rabots Glaciär | 4.22 |
| 13.......... | W. Sarekglaciären | 4.00 |
| 14.......... | S. Akkajekna | 3.94 |
| 15.......... | Mårmaglaciären | 3.93 |
| 16.......... | Vartasjekna | 3.64 |
| 17.......... | Ruopsokjekna | 3.63 |
| 18.......... | Svenonius Glaciär | 3.50 |
| 19.......... | Vuoinesjekna | 3.35 |
| 20.......... | Storglaciären | 3.06 |

***Figure 1.****—Index map of Sweden showing the location of the 20 largest glaciers listed in table 2.*



1986; Naturgeografiska Institutionen, 1987–90). Storglaciären is one of only a very few glaciers in the world in which all three balance terms are known—winter balance, summer balance, and net balance, for each year, starting in 1945–46 (fig. 2). Several other studies have been or are being carried out on Storglaciären: movement, debris content and transport, glacier drainage, crystallography, ice temperatures, and thickness, for example (figs. 3 and 4).

To ensure that Storglaciären is reasonably representative of the glaciers in Lapland, 20 other glacier termini are also surveyed quite regularly, from Kårsajökeln in the north (at 68º22´N. lat) to Salajekna in the south (at 67°08´N. lat). Glacier recession was still taking place in 1981 at all Swedish glaciers, although at a slower rate than was the case during the 1940’s and 1950’s.

## Mapping of Glaciers

In “Die Gletscher Schwedens im Jahre 1908,” Axel Hamberg published a map of the Swedish glaciers (Svenonius and others, 1910), but it was the areal distribution rather than the characteristics of the individual glaciers that was of prime importance to him. At that time it was next to impossible to make a good glacier map, because the National Land Survey maps of the Lappish mountains were all compiled around 1890 and were published at a scale of 1:200,000. There were no railroads at the time, and hardly any roads led to the mountains, so it is remarkable that the cartographers managed to make a map that had all major features in the right place. It is not surprising that many glaciers were not shown and that many snow fields were mapped as glaciers. Anyone who knows what the field conditions were like in the 1880’s and 1890’s can appreciate the difficulties in preparing an accurate topographic map.

The next attempt to map the glaciers was made by Fredrik Enquist in 1918 when he made a study of the height of the glaciation level (Enquist,

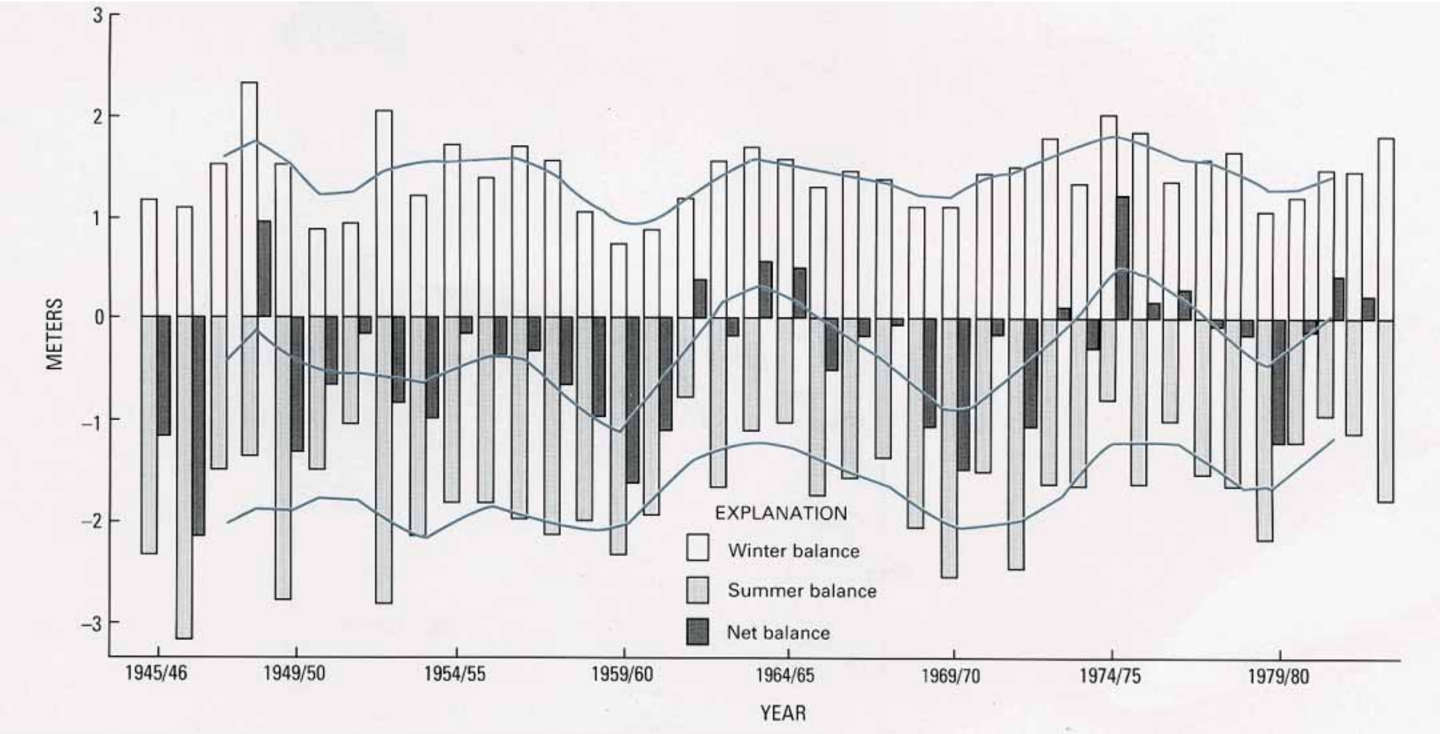



***Figure 2.***—*Winter, summer, and net mass-balance measurements of Storglaciären, Kebnekaise, Lapland, Sweden, for the period **1945–46** through **1983–84.** Summer balance and net balance both show a periodic variation of 12 years. Solid lines indicate a moving 3-year average for winter balance (top), net balance (middle), and summer balance (bottom). The net balance figures indicate glacier recession has been taking place since 1945, but the rate in recent years is slower than in the **1940’s** and **1950’s** (modified from fig. 2 in Schyft, 1981, p. 220).*

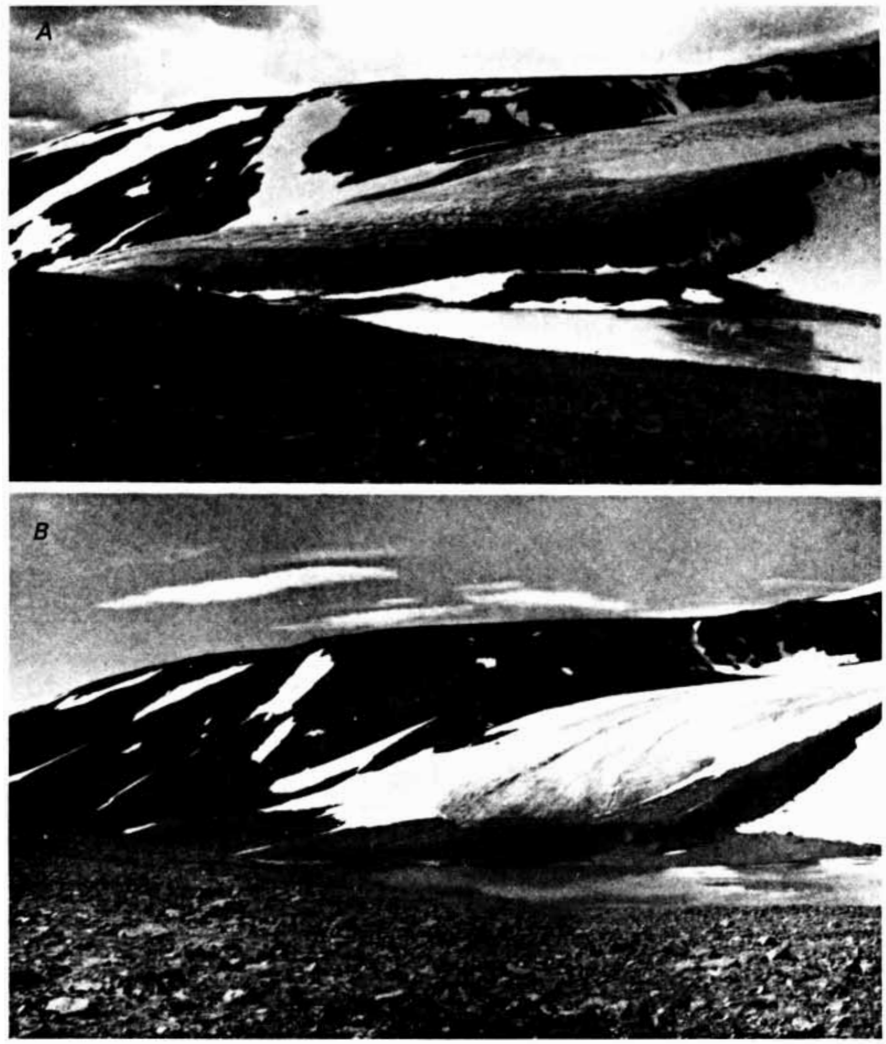



***Figure 3.***—*Terrestrial photographs of the terminus of Storglaciären taken 52 years apart. These two photographs of Storglaciären were taken from the same vantage point, but 52 years separate them in time. When the upper photograph (A) was taken in August 1910 by Fredrik Enquist, the glacier reached all the way down into the valley, and one part extended all the way up the other side. The summer 1962 photograph (B) by Valter Schytt shows a markedly thinned glacier that ends high up on the mountainside a long way from its "days of glory," as shown by the huge terminal and lateral moraines (from Schytt, 1963).*

1918). However, his map shows all glacierized mountainous areas in Sweden but not the individual glaciers themselves.

The poor-quality topographic maps available made good glacier inventories more or less impossible. A few glaciers were mapped quite well during the early half of the century (Kårsajökeln in 1925 and 1943; Storglaciären in 1910, 1922, and 1949), but the topographic maps could not be adjusted to accept this detailed information.

In 1958, however, the entire mountainous part of western Sweden was photographed at a scale of 1:65,000 by the Swedish Air Force at the request of the National Land Survey. These aerial photographs were used for the preparation of the first modern glacier inventory of Sweden by this author. Schytt's map in Geografiska Annaler (Schytt, 1959) was the first detailed compilation. However, his map, as well as Vilborg's improved version in 1962, was based on the older topographic map sheets and could not possibly attain a very high degree of accuracy.

A great step forward was taken in 1973, when the "Atlas over breer i Nord-Skandinavia" ["Atlas of Glaciers in Northern Scandinavia"] was published by Østrem and others (1973). Melander, who was responsible for the Swedish part of this comprehensive inventory, used a completely new set of 1:100,000-scale photogrammetric maps of very good quality, with most of the glaciers already well portrayed. The photographic coverage was also far better, both in terms of higher quality and larger scale, than that which was available to the author in the late 1950's. Schytt's map (1959) was published at a scale of 1:600,000, and the glacier atlas contains maps with scales of 1:1,500,000, 1:600,000, 1:500,000, and 1:250,000. The glacier atlas and the ordinary topographic maps together give a very good record of the shape and extent of Swedish glaciers during the 1960's.

Besides the small-scale maps of the regional glacier inventory, a few of the Swedish glaciers have also been mapped at larger scales for scientific purposes. Kårsajökeln, for example, was mapped by Hans Ahlmann in 1926 (Ahlmann, 1929); by this author, based on 1943 aerial photographs (Wallén, 1948); and by the Durham University Exploration Society in 1961 (Schytt, 1963). Storglaciären was mapped by terrestrial photogrammetry from photographs acquired in 1910 (fig. 3A) and 1949, by aerial photogrammetry from photographs acquired in 1959, 1969 (fig. 5), and 1980, and by radio-echosounding methods in 1979 (Björnsson, 1981) (fig. 4).

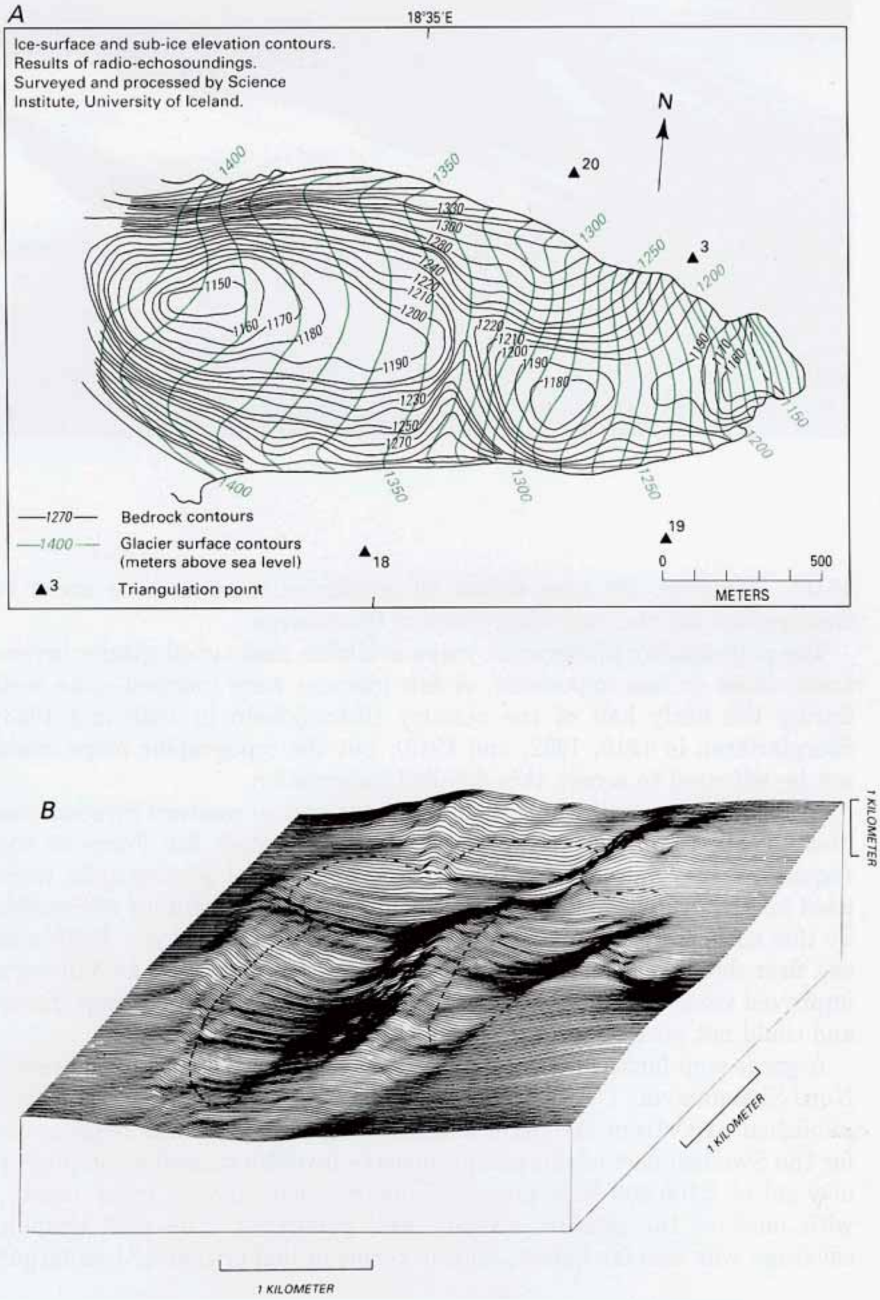



**Figure 4.**—A, *Map of the lower part of Storglaciären showing the results of radio-echosounding. Ice-surface and subglacial-bedrock elevation contours plotted at 10-m intervals.* B, *Isometric diagram of the subglacial bedrock topography of Storglaciären (left) and Isfallsglaciären (right) derived from radio-echosounding data. The dashed line shows the present margin of the two glaciers (from figs. 3 and 4 in Björnsson, 1981, p. 227).*

## TARFALA RESEARCH STATION, SWEDEN

The Tarfala Research Station in the Kebnekaise area of Sweden is the principal field research facility for long-term observations of Swedish glaciers. The station is situated about 150 km north of the Arctic Circle at lat 67° 54′ N., long 18° 34′ E. (60 km west of Kiruna, or 30 km by foot-trail from the village of Nikkalaukta) and provides ready access to the surrounding glacierized region. The mass balance of Storglaciären, for example, has been measured every year since 1946, the longest continuous series for any of the Earth's glaciers. At any one time, a number of large and small field-based research projects in various scientific specialties are underway at the station; these are carried out by established scientists and students from many different countries. The Tarfala Research Station can accommodate about 35 people at one time and is operated by the Department of Physical Geography at the University of Stockholm. (Information derived from a brochure on the "Tarfala Research Station" provided to the editors by Per Holmlund.)

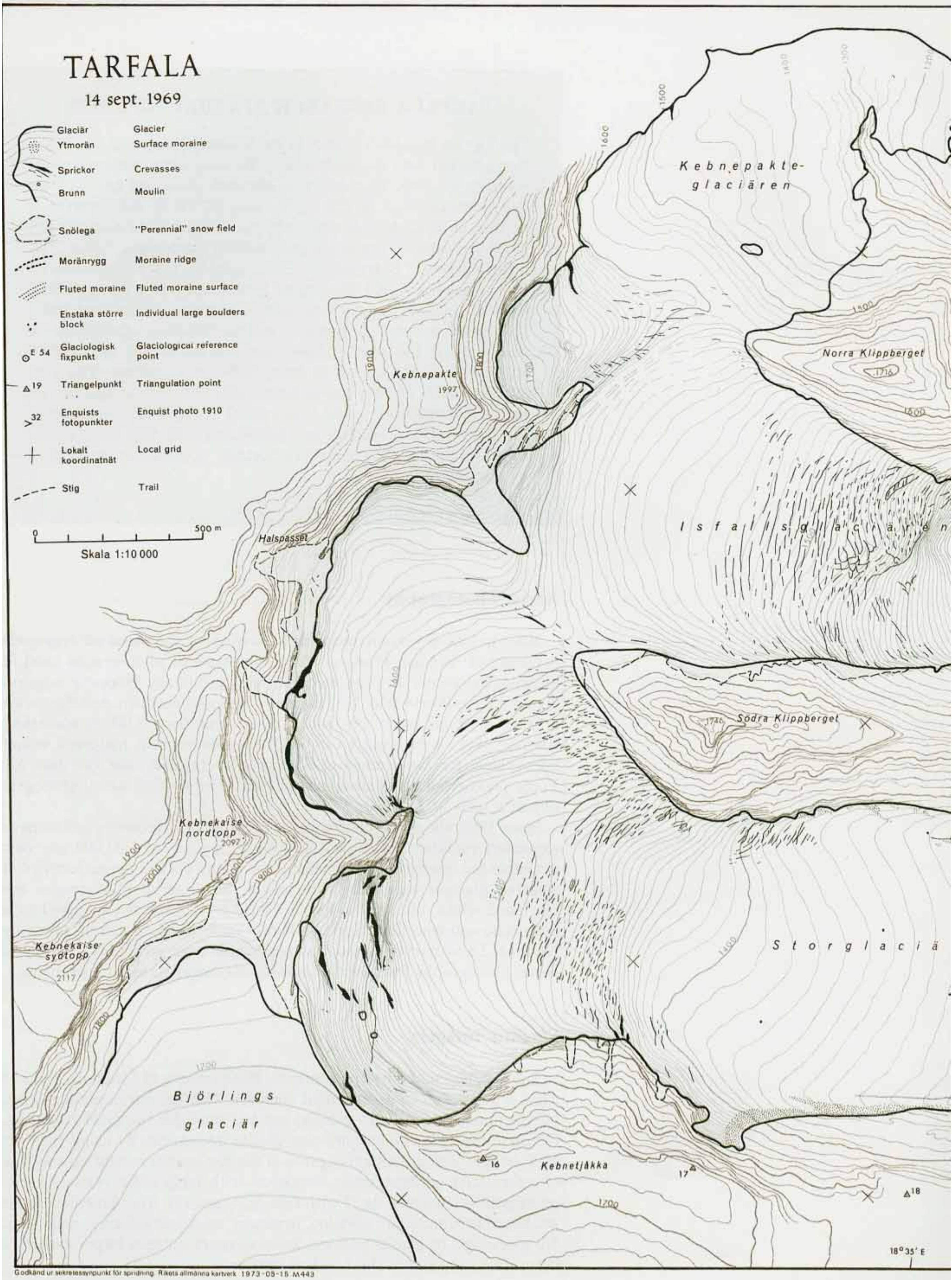
## Aerial Photography

Much has already been mentioned above about the aerial photographic coverage of Swedish glaciers. The earliest aerial photographs used in glaciological research were made to satisfy military mapping requirements during World War 11. They were exposed on 18-cm roll film (with a frame of 18 cm by 18 cm) with a 10-cm lens from 3,000 m elevation. Because they were acquired in 1943, they have great historical value, particularly for the studies of Kårsajökeln. In 1958, the Swedish Air Force photographed all Swedish mountains by vertical aerial photography at a scale of 1:65,000.

Since 1960, the aerial photographic archives of Sweden's glaciers have expanded rapidly. Aerial photographs at a scale of 1:30,000 are now available for nearly all the glaciers, and many special aerial surveys of selected glaciers have also been made. Most aerial photographs are black-and-white, but several glaciers have now been photographed with false color-infrared film. Special photographic missions can be flown by National Land Survey aircraft at reasonable cost, so the availability of aerial photographs for special studies is no longer much of a problem.

## Satellite Imagery

The Landsat multispectral scanner (MSS) images of Sweden's glaciers (figs. 6 and 7 and table 3) cannot compete with the aerial photographs, because most of Sweden's glaciers are too small for the pixel resolution (79 m) of the MSS. To prepare new glacier inventories by using Landsat MSS images is not practical because of the low spatial resolution and lack of information content when compared with large-scale vertical aerial photographs (compare fig. 7 with figs. 8, 9, and 10). The same is true for studies of accumulation, ablation, drainage, morainic features, and so on. No glaciologic or glacial geologic features cover an area large enough to be properly imaged in the Landsat images.


TARFALA
14 sept. 1969
Glaciär Glacier
Ytmorän Surface moraine
Sprickor Crevasses
Brunn Moulin
Snölega "Perennial" snow field
Moränrygg Moraine ridge
Fluted moraine Fluted moraine surface
Enstaka större block Individual large boulders
Glaciologisk fixpunkt Glaciological reference point
Triangelpunkt Triangulation point
Enquists fotopunkter Enquist photo 1910
Lokalt koordinatnät Local grid
Stig Trail
Skala 1:10 000
500 m
Kebnepakte-glaciären
Kebnepakte
1997
Norra Klippberget
Halspasset
Isfallsglaciären
Södra Klippberget
Kebnekaise nordtopp
2097
Kebnekaise sydtopp
2117
Storglaciä
Björlings glaciär
Kebnetjåkka
18°35' E
Godkänd ur sekretessynpunkt för spridning. Rikets allmänna kartverk 1973-05-15 M443

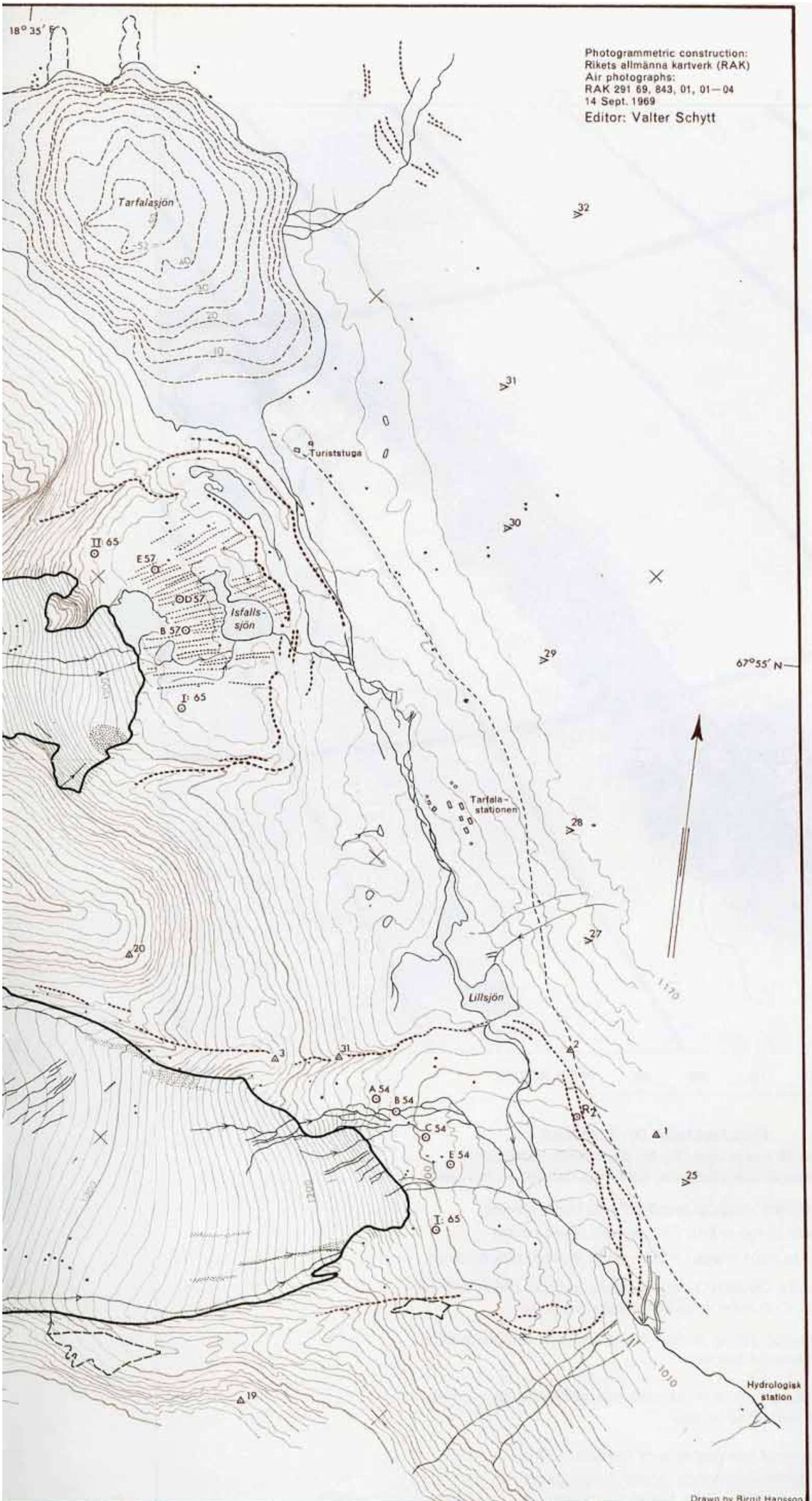
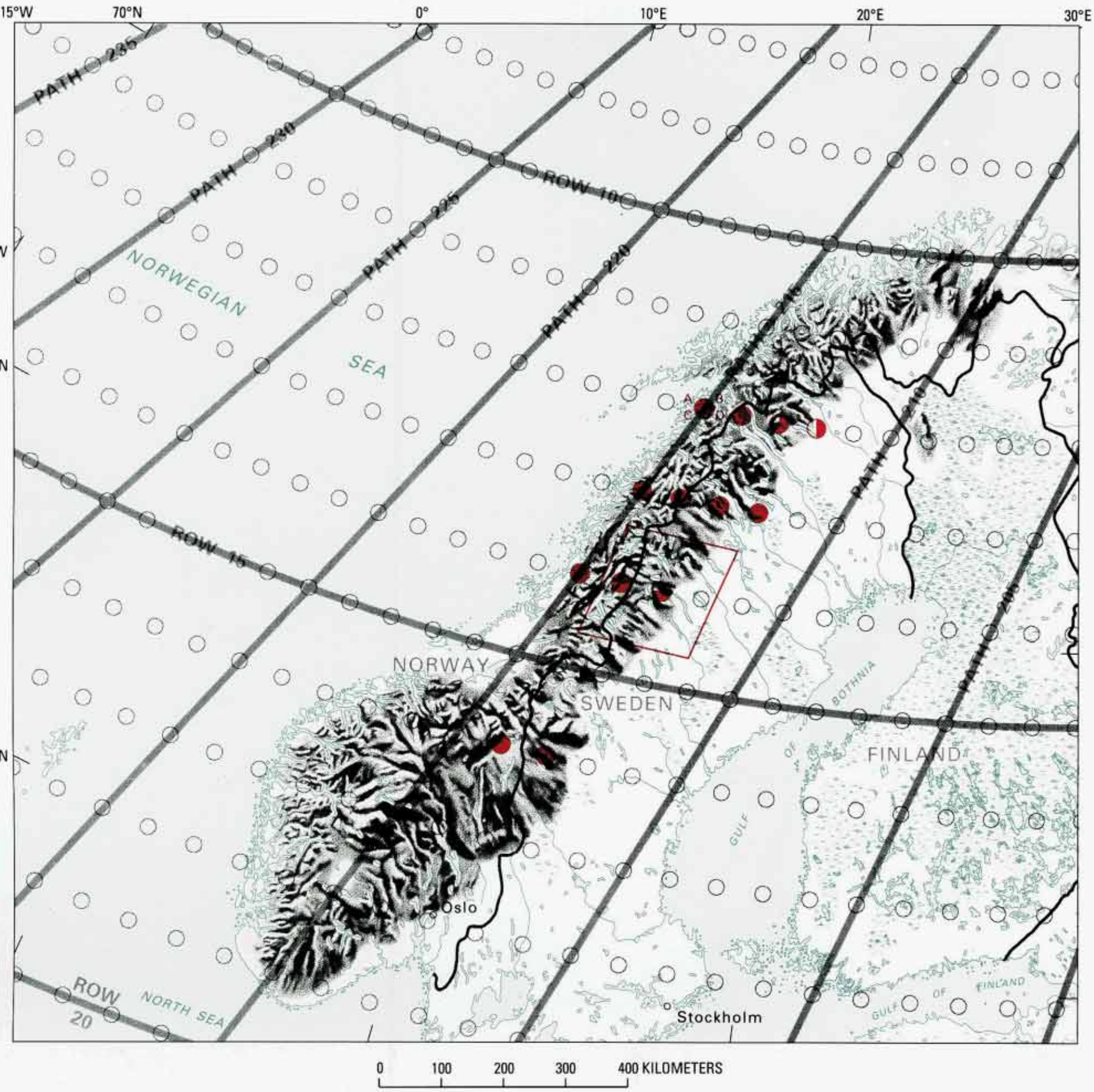



***Figure 5.*–***A portion of the map of the* ***Tarfala*** *Valley area and part of the Kebnekaise massif area, Sweden, compiled by stereophotogrammetric methods from the 14 September 1969 vertical aerial photographs (Schytt, 1973). Storglaciären is the largest (3.06 km²) of the glaciers originally mapped at a scale of 1:l0,000.*




EXPLANATION OF SYMBOLS

Evaluation of image usability for glaciologic, geologic, and cartographic applications. Symbols defined as follows:

- Excellent image (0 to ≤5 percent cloud cover)
- Good image (>5 to ≤10 percent cloud cover)
- Fair to poor image (>10 to ≤100 percent cloud cover)
- A B C D Usable Landsat 3 return beam vidicon (RBV) scenes A, B, C, D refer to usable RBV subscenes
- Nominal scene center for a Landsat image outside the area of glaciers
- Approximate size of area encompassed by nominal Landsat MSS image

***Figure 6.–****Optimum Landsat 1, 2, and 3 images of the glaciers of Sweden. The vertical lines represent nominal paths. The rows (horizontal lines) have been established to indicate the latitude at which the imagery has been acquired.*

**TABLE 3.** –*Optimum Landsat 1, 2, and 3 images of the glaciers of Sweden*

[See fig. 6 for explanation of symbols used in the "Code" column]

| Path-Row | Nominal scene center (lat-long) | Landsat identification number | Date | Solar elevation angle (in degrees) | Code | Cloud cover (in percent) | Remarks |
|---|---|---|---|---|---|---|---|
| 212–12 | 067°59'N. 020°03'E. | 1367-09545 | 25 Jul 73 | 40 | ◑ | 50 | |
| 212–13 | 066°40'N. 018°25'E. | 12081–09023 | 19 Sep 76 | | ● | 0 | Sarek; archived by ESA[1]; not physically examined |
| 213–12 | 067°59'N. 018°37'E. | 1350-10005 | 08 Jul 73 | 43 | ◕ | 10 | Kebnekaise, Storglaciären, Kårsajökeln; image used for figure 6 |
| 213–13 | 066°40'N. 016°59'E. | 20940–09255 | 19 Aug 77 | | ● | 0 | Archived by ESA; not physically examined |
| 213–14 | 065°20'N. 015°30'E. | 1422–10003 | 18 Sep 73 | 25 | ◕ | 10 | |
| 213–16 | 062°38'N. 012°56'E. | 1422–10012 | 18 Sep 73 | 28 | ● | 0 | Sylarne |
| 214–12 | 067°59'N. 017°11'E. | 22075-09543 | 27 Sep 80 | 19 | ◑ | 20 | Archived by ESA |
| 214–12 | 067°59'N. 017°11'E. | 31612–09582 | 03 Aug 82 | 38 | ● | 0 | Partial scene (75%) includes eastern glacier areas; archived by ESA |
| 214–13 | 066°40'N. 015°33'E. | 21301–09361 | 15 Aug 78 | 35 | ◑ | 20 | Archived by ESA |
| 214–13 | 066°40'N. 015°33'E. | 31612–09585 | 03 Aug 82 | 39 | ● | 0 | Partial scene (75%) includes eastern glacier areas; archived by ESA |
| 214–14 | 065°20'N. 014°04'E. | 20941–09320 | 20 Aug 77 | | ● | 0 | Archived by ESA; not physically examined |
| 214–16 | 062°38'N. 011°30'E. | 12047–09181 | 16 Aug 76 | | ● | 0 | Archived by ESA; not physically examined |
| 215–12 | 067°59'N. 015°45'E. | 30893-09503–ABCD | 14 Aug 80 | 35 | A B ○ C D | 10-70 | Landsat 3 RBV |
| 215–12 | 067°59'N. 015°45'E. | 31613–10041 | 04 Aug 82 | 38 | ● | 0 | Partial scene, includes all glacier areas; archived by ESA |
| 215–13 | 066°40'N. 014°06'E. | 2186-10005 | 27 Jul 75 | 41 | ● | 0 | Salajekna |
| 215–14 | 065°20'N. 012°38'E. | 2186-10012 | 27 Jul 75 | 42 | ● | 0 | |

[1]ESA is the abbreviation for the European Space Agency.


***Figure 7.***—*Annotated 1:500,000-scale enlargement of a Landsat image (1350–10005; band 7; 8 July 1973: Path 213, Row 12) of the Storglaciären and other glaciers in the Kebnekaise massif area. The area of figure 8 is outlined. Four of the 20 largest glaciers of Sweden listed in table 2 and located in figure 1 are in the Kebnekaise area.*

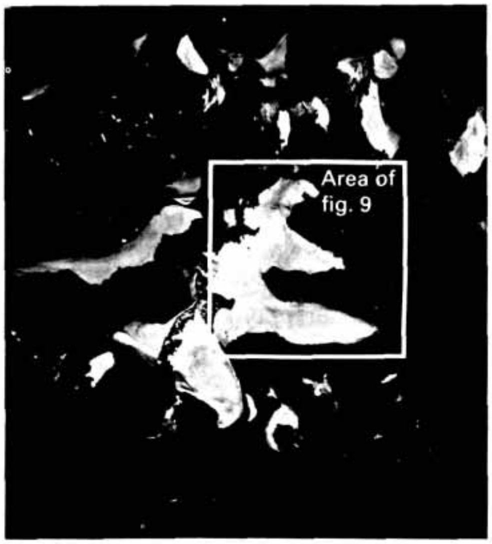



*Figure 8.*–Vertical aerial photograph of the Kebnekaise massif and its glaciers on 29 August 1972. The survey aircraft flew at an altitude of 6,000 m above sea level. The camera focal length was 4.4 cm. The approximate scale of the photograph at Storglaciären is 1:150,000. The area of figure 9 is outlined; see also figure 7. Photograph no. 92–256-11–15, courtesy of the Swedish Air Force.


*Figure 9.*–Part of a vertical aerial photograph of the central part of the Kebnekaise massif on 29 July 1980, with Storglaciären in the lower part of the photograph. The area of figure 10 is outlined. Approximate scale is 1:40,000. See also figures 7, 8, and 10 for the comparison in glaciological information available with the larger scale aerial photographs and the satellite image. Photograph No. 80–537–11-04 (SV 298) courtesy of the Swedish National Land Survey (Lantmäteriverket).

*Figure 10.*– Vertical aerial photograph of the terminus of Storglaciären on 22 August 1968. Approximate scale is 1:8,000. Photograph No. OY8–764-6–2, courtesy of the Swedish Air Force.

# Conclusions

The need for a good glacier map of Sweden was satisfied when the "Atlas of Glaciers in Northern Scandinavia" was published (Østrem and others, 1973). Besides containing a suite of glacier maps at scales of 1:1,500,000, 1:600,000, 1:500,000, and 1:250,000, this atlas also contains a wealth of information on each glacier, such as length, area, elevation, morainal features, glacier lakes, and glacier orientation. Over the Earth's large ice sheets, satellite images can do what no aerial photographic survey can do. In Arctic regions or remote mountains, satellite images can also be extremely valuable in the study of ice fields and ice caps. For small glaciers, especially those readily accessible to glaciologists in highly developed countries, Landsat MSS images have only limited value mainly due to spatial resolution limitations. Also, small glaciers in developed countries are often photographed at regular intervals during the course of regional aerial photogrammetric or thematic mapping surveys. Stereopairs of large-scale vertical aerial photographs are the best source material for the study of these smaller glaciers. Even in the future, when higher resolution (1:50,000-scale, 8-m spatial resolution) stereopairs of satellite photographs become available (for example, Large Format Camera photographs), it seems likely that larger scale vertical aerial photographs of the smaller glaciers will still be more useful than satellite photographs.

# Acknowledgments

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# References Cited


Ahlmann, H.W:son, 1929, Kårsajökeln. Karta i skalan 1:20,000 jämte vägledning för besökande [Kårsajökeln. A map at 1:20,000-scale including a guide for visiting the area]: Svenska Turistföreningen Publication No. 451, p. 14.

Björnsson, H., 1981, Radio-echosounding maps of Storglaciären, Isfallsglaciären and Rabots Glaciär, northern Sweden: Geografiska Annaler, v. 63A, no. 3–4, p. 225–231.

Enquist, F., 1918, Die glaziale Entwicklungsgeschichte Nordwestskandinaviens [The glacial history of northwestern Scandinavia]: Sveriges geologiska undersökning, Series C, no. 285, Årsbok 12, no. 2, p. 1–143.

Grudd, H., and Jansson, P., 1986, The 1984/85 mass balance of Storglaciären, Kebnekaise, Swedish Lapland: University of Stockholm, Department of Physical Geography, 13 p.

Hamberg, A., 1896, Berättelse om en resa i Sarekfjällen [Report of a trip to the Sarek Highlands]: Svenska Turistföreningens årsbok 1896, p. 152–192.

Naturgeografiska Institutionen, 1987, Årsrapport från Tarfala forskningsstation 1986, Jansson, P., ed.: Stockholm, University of Stockholm, 95 p.

———1988, Årsrapport 1987: Tarfala research station, Rosqvist, G., ed.: Stockholm, University of Stockholm, 103 p.

———1989, Årsrapport 1988 Tarfala research station, Stroeven, A., ed.: Stockholm, University of Stockholm, 85 p.

———1990, Årsrapport 1989 Tarfala research station, Stroeven, A., and Eriksson, M., eds.: Stockholm, University of Stockholm, 76 p.

Østrem, G., Haakensen, N., and Melander, O., 1973, Atlas overbreer i Nord-Skandinavia [Atlas of glaciers in northern Scandinavia]: Meddelelse nr. 22 fra Hydrologisk avdeling, Norges Vassdrags-og elektrisitetsvesen; also published as Meddelande nr. 46 från Naturgeografiska Institutionen, Stockholms Universitet, 315 p. [In Norwegian, Swedish, and English].

Schytt, V., 1959, The glaciers of the Kebnekajse-massit Geografiska Annaler, v. 41, no. 4, p. 213–227.

———1963, Glaciärernas liv [The life of glaciers]: Svenska Turistföreningens Årsskrift 1963, p. 144–158.

———ed., 1973, Tarfala. 14 Sept. 1969 (Special 1:10,000-scale map of glaciers in the central part of the Kebnekaise massif, Lapland, Sweden): Stockholm, AB Kartografiska Institutet.

———1981, The net mass balance of Storglaciären, Kebnekaise, Sweden, related to the height of the equilibrium line and to the height of the 500 mb surface: Geografiska Annaler, v. 63A, no. 3-4, p. 219–223.

Svenonius, F., Westman, J., Hamberg, A., Gavelin, A., and Enquist, F., 1910, Die Gletscher Schwedens im Jahre 1908 [The Swedish glaciers in the year 19081: Stockholm, Kungl. boktryckeriet, P.A. Norstedt och söner. Sveriges geologiska undersökning, Series Ca (Avhandlingar och uppsatser i kvarto och folio), no. 5, in 6 parts, 212 p. (I. Studien über den Kårso und die Kebnegletscher nebst Notizen über andere Gletscher im Jukksajärvigebirge [Studies of the Kårsa and Kebne glaciers with notes about other glaciers in the Jukkasjärvi Mountains], by Fredrik Svenonius; 11. Beobachtungen über die Sulitälmagletscher im Sommer 1908 [Observations of the Sulitälma glaciers in the summer of 1908], by Jonas Westman; 111. Die Gletscher des Sarekgebirges und ihre Untersuchung. Eine kurze Übersicht [Investigation of the glaciers of the Sarek Mountains. A short review], by Axel Hamberg; IV. Über die Gletscher des Norra Storfjället und des Ammarfjället [The glaciers of northern Storfjället and Ammarfjället], by Axel Gavelin; V. Über die jetzigen und ehemaligen lokalen Gletscher in den Gebirgen von Jämtland und Härjedalen [The present and former glacier locations in the mountains of Jämtland and Härjedalen], by Fredrik Enquist; VI. Kurze Übersicht der Gletscher Schwedens [A short review of the Swedish glaciers], by Axel Hamberg.)

Vilborg, L., 1962, The recent glaciation in Sweden: Geografiska Annaler, v. 44, no. 3-4, p. 405-406.

Wahlenberg, G., 1808, Berättelse om mätningar och observationer for att bestämma lappska fjällens höjd och temperatur vid **67** graders polhöjd, förrättade år 1807[Report on the measurements and observations to determine the height of the Lappish Mountains and the temperature near 67° latitude, carried out in 18071: Stockholm, 58 p.

Wallén, C.C., 1948, Glacial-meteorological investigations on the Kårsa G1acier in Swedish Lapp1and 1942-1948: Geografiska Anna1er, v. 30, no. 3 - 4 , p. 453–672.